US009169711B2

(12) **United States Patent**
Raynal et al.

(10) **Patent No.: US 9,169,711 B2**
(45) **Date of Patent: Oct. 27, 2015**

(54) **SLOTTED METAL SEAL**

(71) Applicant: **Vetco Gray Inc**, Houston, TX (US)

(72) Inventors: **Jeffrey Allen Raynal**, Houston, TX (US); **Nicholas Peter Gette**, Houston, TX (US); **Philip John Potter**, Houston, TX (US); **Daniel Caleb Benson**, Houston, TX (US); **David Lawrence Ford**, Houston, TX (US)

(73) Assignee: **Vetco Gray Inc.**, Houston, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 335 days.

(21) Appl. No.: **13/678,166**

(22) Filed: **Nov. 15, 2012**

(65) **Prior Publication Data**

US 2014/0131054 A1 May 15, 2014

(51) **Int. Cl.**

E21B 33/04	(2006.01)
E21B 33/03	(2006.01)
E21B 33/00	(2006.01)

(52) **U.S. Cl.**

CPC ***E21B 33/04*** (2013.01); ***E21B 33/03*** (2013.01); *E21B 2033/005* (2013.01)

(58) **Field of Classification Search**

CPC E21B 2033/005; E21B 33/02; E21B 33/03
USPC 166/387, 368, 379, 75.13, 85.3, 86.1, 166/217; 277/328, 626, 647
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,595,053	A	6/1986	Watkins et al.	
4,665,979	A	5/1987	Boehm, Jr.	
4,742,874	A *	5/1988	Gullion	166/348
4,790,572	A	12/1988	Slyker	
4,932,472	A	6/1990	Boehm, Jr.	
4,949,786	A	8/1990	Eckert et al.	
4,960,172	A *	10/1990	Nelson	166/208
5,067,734	A *	11/1991	Boehm, Jr.	277/328
5,285,853	A	2/1994	Eckert et al.	
5,456,314	A	10/1995	Boehm, Jr. et al.	
5,685,369	A	11/1997	Ellis	
6,367,558	B1	4/2002	Borak, Jr.	
7,762,319	B2	7/2010	Nelson	
7,861,789	B2	1/2011	Nelson	
8,146,670	B2	4/2012	Ellis	
8,186,426	B2	5/2012	Nelson	

(Continued)

FOREIGN PATENT DOCUMENTS

GB	2180016	A	3/1987
GB	2462520	A	2/2010
GB	2489593	A	10/2012

OTHER PUBLICATIONS

PCT Search Report and Written Opinion issued Apr. 22, 2014 in connection with corresponding PCT Patent Application No. PCT/US2013/067718.

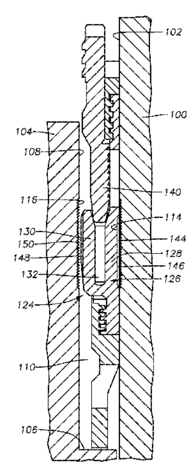
Primary Examiner — Jennifer H Gay

(74) *Attorney, Agent, or Firm* — Bracewell & Giuliani LLP

(57) **ABSTRACT**

A seal for sealing an annulus between an outer tubular wellhead member and an inner tubular wellhead member is described. The seal is an annular sealing ring that has a plurality of circumferentially spaced apart sealing ring grooves extending at least from a first end to a second end of the sealing surface of at least one of the wellhead members. When the seal is energized, fouling on the sealing surface is urged toward and then through the slot, axially away from the sealing surface.

20 Claims, 4 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

8,205,670	B2	6/2012	Nelson	
8,205,671	B1 *	6/2012	Branton	166/118
8,636,072	B2 *	1/2014	Gette et al.	166/341
8,851,194	B2 *	10/2014	Ford et al.	166/387
2010/0038089	A1	2/2010	Gette	
2010/0052261	A1 *	3/2010	Maldonado	277/322
2010/0116489	A1	5/2010	Nelson	
2010/0300705	A1 *	12/2010	Nelson	166/387
2010/0327532	A1 *	12/2010	Thomson	277/328
2011/0174506	A1	7/2011	Duong	
2011/0316236	A1	12/2011	Gette	
2012/0025470	A1	2/2012	Gette	
2012/0085554	A1	4/2012	Gette	
2012/0098203	A1	4/2012	Duong	
2012/0118585	A1	5/2012	Duong	
2012/0241175	A1	9/2012	Galle	
2012/0247788	A1	10/2012	Ford	
2013/0093140	A1 *	4/2013	Gette et al.	277/323
2014/0096977	A1 *	4/2014	Gette et al.	166/379
2014/0131054	A1 *	5/2014	Raynal et al.	166/387
2014/0183824	A1 *	7/2014	Benson et al.	277/328
2014/0238699	A1 *	8/2014	Gette et al.	166/387

* cited by examiner

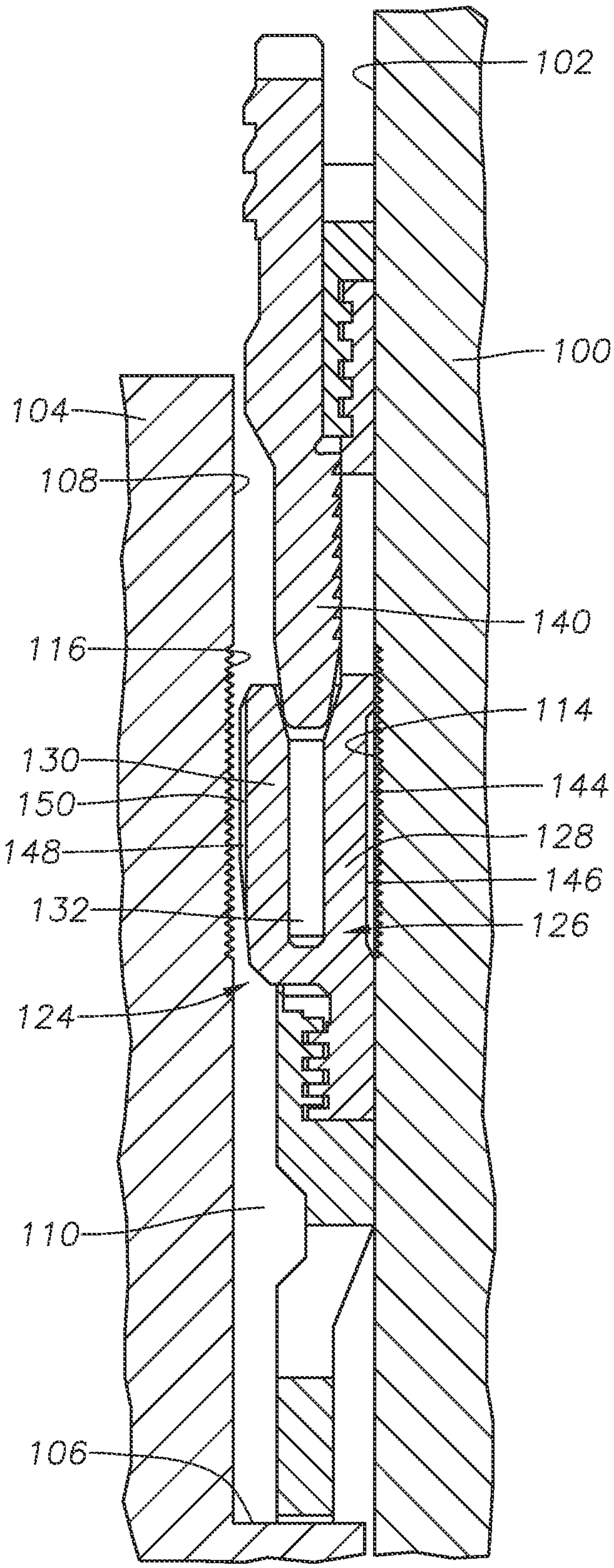

102
100
104
108
140
116
114
130
144
150
128
148
146
132
126
124
110
106

FIG. 1

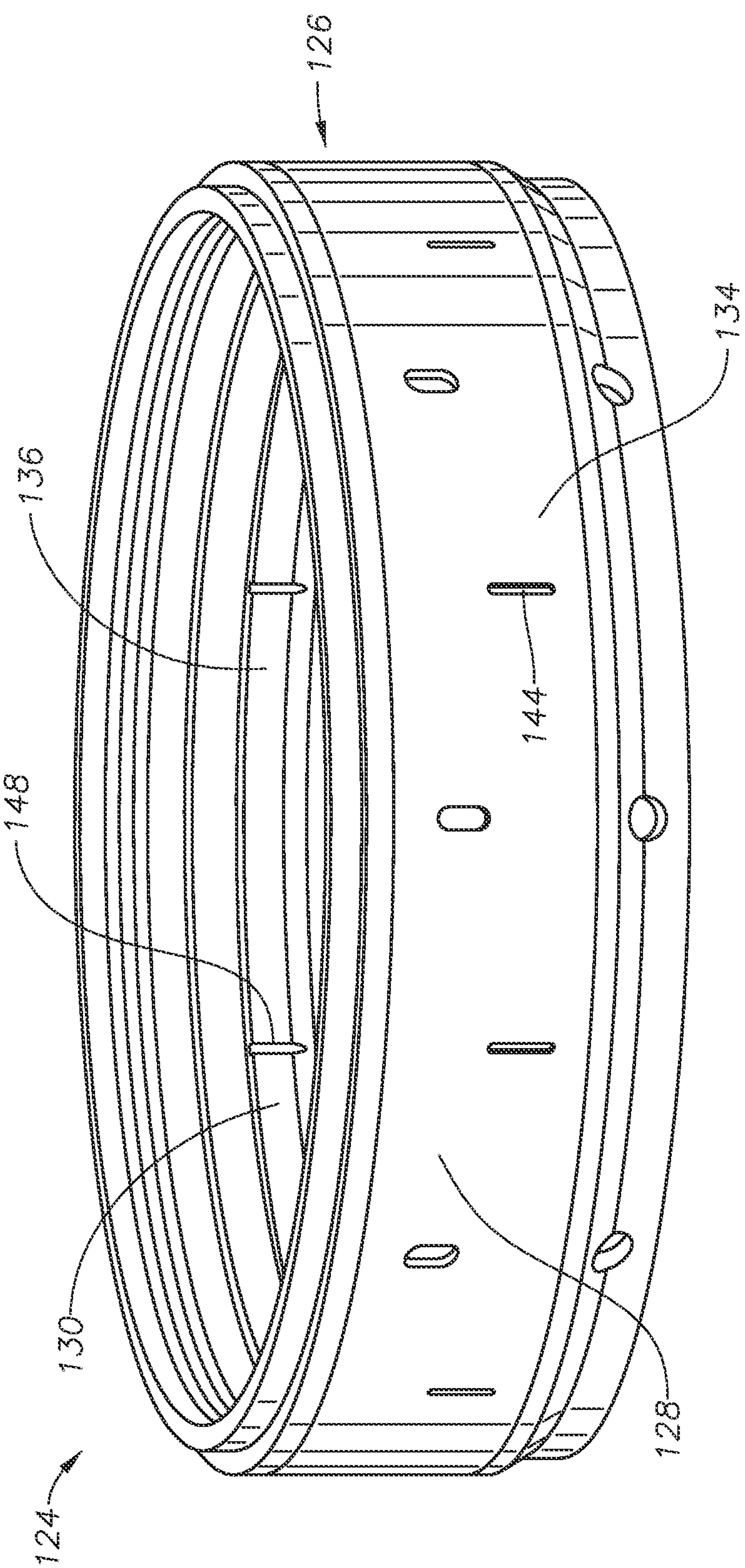


FIG. 2

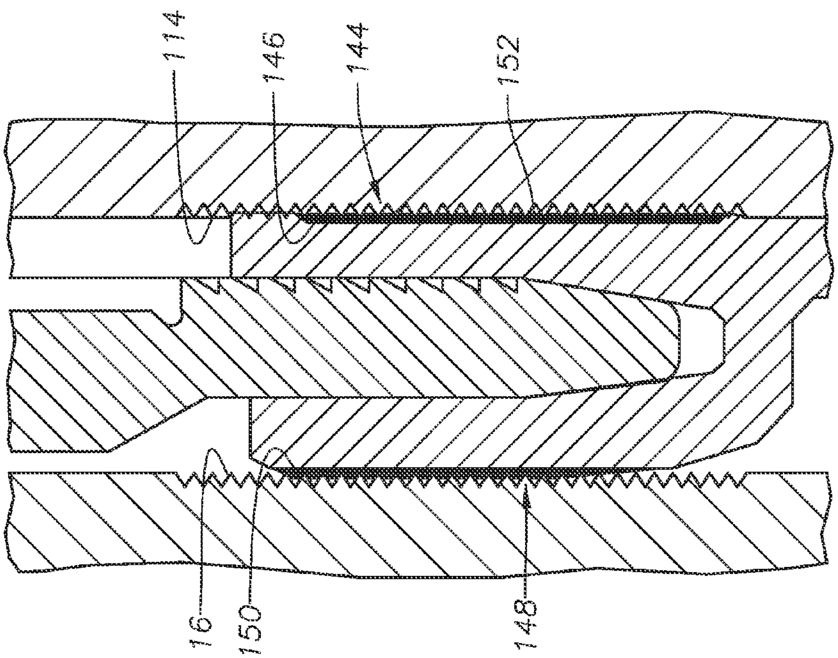


FIG. 4

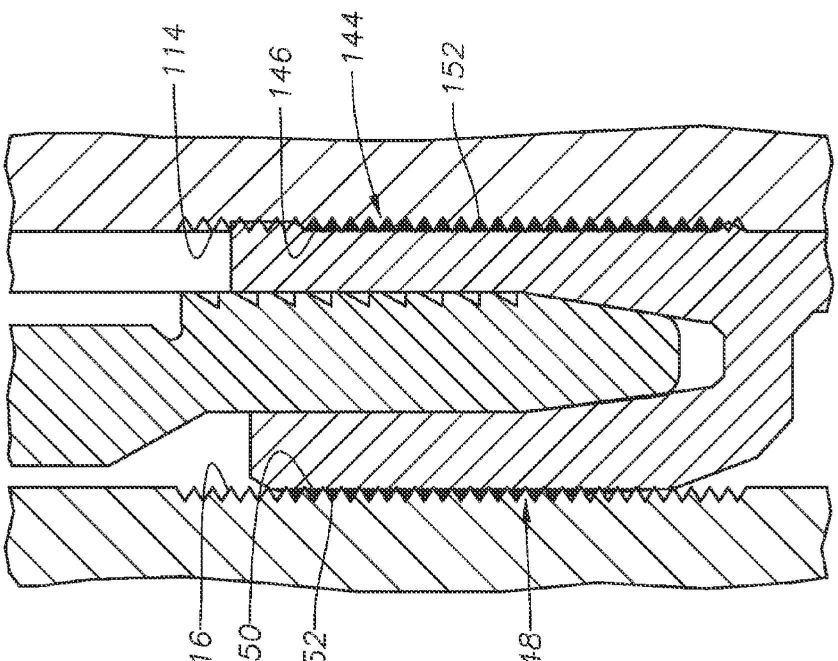


FIG. 3

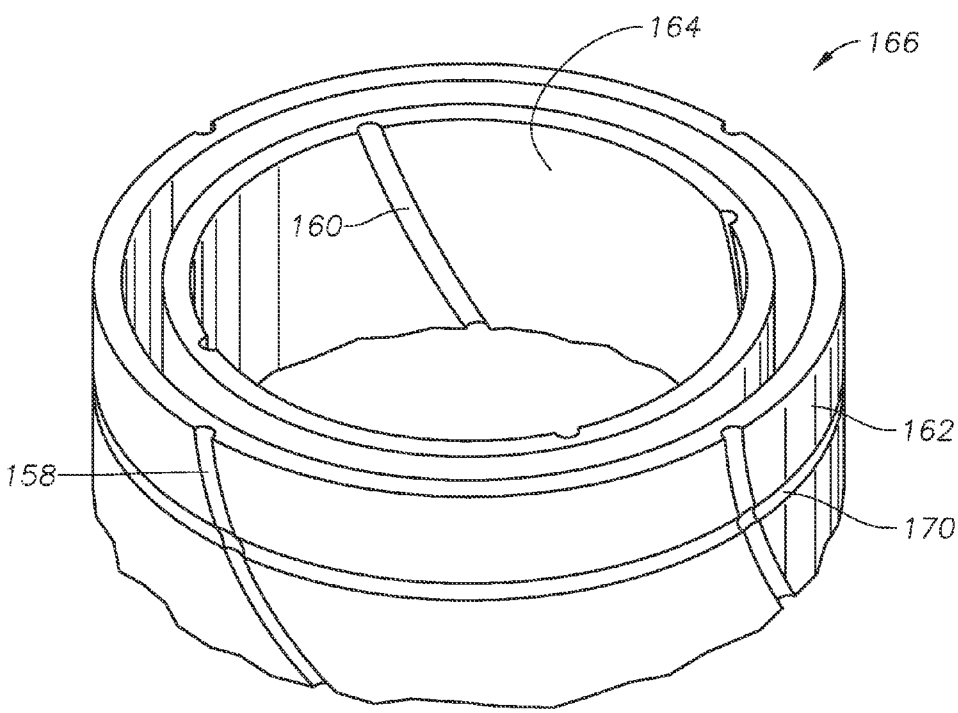


FIG. 5

SLOTTED METAL SEAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates in general to mineral recovery wells, and in particular to a seal for sealing between wellbore members.

2. Brief Description of Related Art

In hydrocarbon production wells, a housing such as a wellhead housing or high pressure housing is located at the upper end of the well. The wellhead housing is a large tubular member having an axial bore extending through it. Casing will extend into the well and will be cemented in place. A tubing hanger, which is on the upper end of the casing, will land within the wellhead housing. The exterior of the tubing hanger is spaced from the bore of the wellhead housing by an annular clearance which provides a pocket for receiving an annulus seal.

There are many types of annulus seals, including rubber, rubber combined with metal, and metal-to-metal. One metal-to-metal seal in use has a U-shape, having inner and outer walls or legs separated from each other by an annular clearance. An energizing ring, which has smooth inner and outer diameters, is pressed into this clearance to force the legs apart to seal in engagement with the bore and with the exterior of the tubing hanger.

Some annular seals utilize wickers. Wickers may be located on the exterior of the tubing hanger, in the bore of the wellhead housing, or both. The outer leg of the seal embeds into the wickers of the bore while the inner leg of the seal embeds into the wickers of the tubing hanger. This locks the annulus seal in place, providing axial restraint, as well as forming a seal.

The sealing wickers are machined directly into the bore of the high pressure housing and landing subs or the neck of the tubing hangers. The annulus seal is made of a sufficiently deformable metal to allow it to deform against the wickers of the tubing hanger. The deformation occurs as the wickers "bite" into the annulus seal. In order to cause the seal to deform without damaging the wickers, the annulus seal is made of a metal that is softer than the steel used for the tubing hangers.

Debris, such as wellbore cuttings, may fill the wickers of the high pressure housing during standard drilling operations. Similarly, fluid such as drilling mud, water, or wellbore fluid may be present in the grooves of wickers on the high pressure housing and tubing hanger at the time the seal is set. The debris or fluid, collectively referred to as "fouling," can develop a fluid pressure buildup, also referred to as hydraulic lock, and thus affect the sealing engagement between the annular seal and the sealing surface. It is desirable to be able to clear such fouling when the seal is energized.

SUMMARY OF THE INVENTION

Embodiments of an annulus seal for sealing between two wellbore members, such as a wellhead housing or high pressure housing and a hanger are presented. The seal, such as a "u-cup" or a u-shaped seal, includes vertical or helical slots, or channels, on the sealing surfaces. The slots provide channels for fouling from the sealing surface to escape during seal setting operation. The sealing surfaces of the wellbore members can include wickers, which are parallel circumferential ridges. The seal element will continue to engage wickers until the ends of the wickers engage the bottom of the slots, thus providing a seal with increased lock-down. Fouling, which is fluid or debris, and can include wellbore cuttings, drilling mud, wellbore fluid, water, and the like, can be present on the sealing surfaces and within the grooves of the high pressure housing and tubing hanger at the time the seal is set.

When the energizing ring engages the u-cup of the seal, it expands the u-cup to energize the seal. Any fouling in the wicker profiles of the housing or tubing hanger is forced out of the wickers and through the slots. Fluid pressure buildup in the wickers is thus relieved, allowing further engagement of the seal into the wicker profile. The further engagement increases the lock-down capacity of the seal. The seal is complete when the wicker profile engages the bottom of the slots. The seal is thus more tolerant of fouling and less susceptible to hydraulic lock than seals that do not provide channels for fouling to escape.

In some embodiments, the slots are filled with a material that is softer than the material of the sealing ring. The material can be a fusible metal alloy such as materials used for soldering applications or an equivalent material. The soft metal substance will flow under high pressures but will reduce the pressure between the seal element and the wickers in the housing. This will allow for more penetration of the wickers into the seal. The sealing is achieved in the final depth of penetration of the wickers, which reduces the area for the soft metal substance to flow. This allows for lock-down and sealing of the annulus seal. Any fouling that is present in the sealing surfaces is urged toward the slots. The fouling then causes the filler to flow, which allows the fouling to also move through the slot and away from the sealing surfaces.

In embodiments, a wellhead assembly includes an outer tubular wellhead member and an inner tubular wellhead member, the inner tubular wellhead member being operable to land within the outer tubular wellhead member, defining a seal pocket between them, and a sealing surface on at least one of the wellhead members. An annular seating ring is adapted to be disposed within the seal pocket, the annular sealing ring having a sealing ring surface operable to be urged against the sealing surface. The sealing ring surface has a plurality of circumferentially spaced apart sealing ring grooves extending from a first end toward a second end of the sealing ring surface.

In embodiments, a plurality of circumferentially extending, parallel ridges can be formed in the sealing surface. In embodiments, the sealing ring is urged toward the sealing surface until the ridges contact a bottom of the sealing ring grooves. The sealing ring grooves can be generally parallel to the axis of the sealing ring. In embodiments, the sealing ring grooves can extend helically from the first end toward the second end of the sealing surface.

Embodiments can have at least one circumferential groove in the sealing ring surface, the circumferential groove extending circumferentially around the sealing ring and intersecting at least one of the sealing ring grooves. The sealing ring grooves can be filled with an inlay of a material different than a material of the sealing ring. In embodiments, the sealing ring is metal and the sealing ring grooves are filled with a second metal, the second metal being softer than the metal of the sealing ring. In embodiments, the sealing surface can be located on an inner diameter of the outer tubular wellhead member and the sealing ring grooves can be on an outer diameter of the sealing ring. The sealing ring can be a u-shaped seal that is energized by an energizing ring.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the features, advantages and objects of the invention, as well as others which will become apparent, are attained and can be understood in more detail, more particular description of the invention briefly summarized above may be had by reference to the embodiment thereof which is illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the drawings illustrate only a preferred embodiment of the invention and is therefore not to be considered limiting of its scope as the invention may admit to other equally effective embodiments.

FIG. **1** is a side sectional environmental view of an embodiment of seal ring having slots, positioned in an annulus between a housing and a wellbore hanger.

FIG. **2** is a perspective view of the seal ring of FIG. **1**.

FIG. **3** is a side sectional view of an embodiment of the seal ring of FIG. **1**, having a filler material in the slots and wickers on a sealing surface engaging the back wall of the slot.

FIG. **4** is a side sectional view of an embodiment of the seal ring of FIG. **1**, having a filler material in the slots and wickers on a sealing surface that form a seal engaging the back wall of the slot.

FIG. **5** is an alternative embodiment of the seal ring of FIG. **1**, showing helical slots and a circumferential slot.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described more fully hereinafter with reference to the accompanying drawings which illustrate embodiments of the invention. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout, and the prime notation, if used, indicates similar elements in alternative embodiments.

Referring to FIG. **1**, a wellhead housing **100** is presented. In the illustrated embodiment, the wellhead housing **100** is a conventional high pressure housing for a subsea well. It is a large tubular member located at the upper end of a well, such as a subsea well. Wellhead housing **100** has an axial bore **102** extending through it. A tubing hanger **104** lands in the wellhead housing **100**. Tubing hanger **104** is a tubular conduit secured to the upper end of a string of casing or wellbore tubing (not shown). Tubing hanger **104** has an upward facing shoulder **106** on its exterior. The exterior wall **108** of tubing hanger **104** is parallel to the wall of bore **102** but spaced inwardly. This results in an annular pocket or clearance **110** between tubing hanger exterior wall **108** and bore **102**. A housing sealing surface **114** is located on an inner diameter of housing **100**. A hanger sealing surface **116** is located on the exterior wall **108** of tubing hanger **104**, radially across bore **102** from housing sealing surface **114**. As one of skill in the art will appreciate, housing sealing surface **114** and hanger sealing surface **116** can have any of a variety of surfaces such as a generally smooth surface, a texture that enhances friction while maintaining a seal, or wickers. Wickers are grooves defined by parallel circumferential ridges and valleys. Wickers are not threads The sealing surfaces **114**, **116** shown in FIG. **1** include wickers.

Referring to FIGS. **1** and **2**, a seal assembly **124** lands in the pocket between tubing hanger exterior wall **108** and bore wall **102**. Seal assembly **124** is made up entirely of metal components or a combination of metal and non-metal components. These components include a generally U-shaped seal member **126**. Seal member **126** has an outer wall or leg **128** and a parallel inner wall or leg **130**, the outer leg **128** and inner leg **130** being connected together at the bottom by a base and open at the top. The inner diameter of outer leg **128** is radially spaced outward from the outer diameter of inner leg **130**. This results in an annular clearance **132** between outer leg **128** and inner leg **130**. The inner diameter and the outer diameter are smooth cylindrical surfaces parallel with each other. The outer diameter of outer leg **128** includes outer sealing surface **134** (FIG. **2**). The inner diameter of inner leg **130** includes inner sealing surface **136** (FIG. **2**).

Referring back to FIG. **1**, an energizing ring **140** is employed to force outer leg **128** and inner leg **130** radially apart from each other and into sealing engagement with housing sealing surface **114** and hanger sealing surface **116**, respectively. The housing sealing surface **114** sealingly engages outer leg **128** and hanger sealing surface **116** sealingly engages inner leg **32** as the energizing ring **140** forces the outer leg **128** and inner leg **130** apart. In embodiments having wickers, the wickers of each sealing surface **114**, **116** bite into outer sealing surface **134** and inner sealing surface **136**, respectively. Energizing ring **140** has an outer diameter that will frictionally engage the inner diameter of outer leg **128**. Energizing ring **140** has an inner diameter that will frictionally engage the outer diameter of inner leg **130**. The radial thickness of energizing ring **140** is greater than the initial radial dimension of the clearance **132**.

Still referring to FIG. **1**, outer diameter ("OD") slot **144** is a vertical slot on an outer diameter of outer leg **128**. As best shown in FIG. **2**, a plurality of OD slots **144** are spaced apart around outer leg **128**. Each OD slot **144** has a slot width, defined by the circumferential span of the width of the slot, and a slot length, defined by the axial length of OD slot **144**. The slot width is substantially smaller than the slot length. The slot length is longer than the portion of the housing sealing surface **114** that engages the OD slots **144**. The OD slots **144** do not pass completely through the sidewall of outer leg **128** of the seal. Rather, each OD slot **144** is a groove having a radial depth defined by OD slot back wall **146**.

Inner diameter ("ID") slot **148** is a vertical slot on an inner diameter of inner leg **130**. As best shown in FIG. **2**, a plurality of ID slots **148** are spaced apart around inner leg **130**. Each ID slot **148** has a slot width, defined by the arc span of the width of the slot, and a slot length, defined by the axial length of ID slot **148**. The slot width is substantially smaller than the slot length. The slot length is longer than the portion of the hanger sealing surface **116** that engages the ID slots **148**. The ID slots **148** do not pass completely through the sidewall of outer leg **128** of the seal. Rather, each slot **144** is a groove having a radial depth defined by ID slot back wall **150**. Slots **144**, **148** can be open slots, not having any kind of a filler, as shown in FIG. **1**. In such embodiments, wickers of sealing surfaces **114**, **116** must engage outer sealing surface **134** and inner sealing surface **136** to a depth such that the wickers contact back walls **146** and **150** of the slots. The wickers, thus, form a continuous seal around u-shaped seal member **126** by preventing fluid from flowing axially along slots **144**, **148**.

Fouling is defined as fluid or debris, and includes wellbore cuttings, drilling mud, wellbore fluid, water, and the like. Fouling can be present on the sealing surfaces and within the wicker grooves of wellhead housing **100** and tubing hanger **104** at the time the seal is set. Prior to the wickers contacting back walls **146** and **150**, any wellbore fouling present on housing sealing surface **114** and hanger sealing surface **116** is urged by the sealing surfaces toward and into slots **144**, **148**. The fouling then travels through slots **144**, **148** to a point that is axially away from sealing surfaces **114**, **116**. The fouling, thus, is moved away so that it does not develop a fluid pressure buildup and, thus, interfere with the seal between sealing surfaces **114**, **116** and sealing surfaces **134**, **136**, respectively.

Referring to FIG. **3**, OD slots **144** and ID slots **148** can be filled with a filler **152**, such as a metal that is softer than the metal of the u-shaped seal member. An example of such metal filler is a fusible metal alloy such as those found in soldering applications including, for example, tinindium. In embodiments having slots filled with filler **152**, sealing surfaces **114**, **116** engage the u-shaped seal member to form a continuous seal against outer sealing surface **134** (FIG. **2**) and inner sealing surface **136** (FIG. **2**), with filler **152** sealing slots **144** and **148**. Because the filler is used only in slots, and does not cover the entirety of sealing surfaces **134** and **136**, housing sealing surface **114** and hanger sealing surface **116** are each able to engage the harder metal of sealing surfaces **134** and **136**, respectively, and thus provide full lockdown capabilities. In the event that fouling is present on outer sealing surface **134** or inner sealing surface **136**, the fouling is urged toward OD slots **144** and ID slots **148**, respectively. Because filler **152** is sufficiently soft, the fouling can displace at least a portion of the filler, causing the filler to flow and allowing the fouling to be urged through slots **144** or **148** away from sealing surfaces **134** and **136**. As shown in FIG. **3**, in embodiments having wickers on sealing surfaces **114**, **116**, the tips of those wickers can bite into sealing surfaces **114**, **116** to a depth such that the tips contact back walls **146** and **150**, respectively. The engagement between the wickers and sealing surfaces **134**, **136** (FIG. **2**) help to lock the seal in place and, thus, resist axial movement of the seal.

Referring to FIG. **4**, in embodiments having filled slots **144**, **148** and wickers on sealing surfaces **114**, **116**, the wickers do not necessarily need to contact OD slot back wall **146** and ID slot back wall **150** to form a seal when those wickers bite into sealing surfaces **134** and **136**. In such embodiments where the wickers of sealing surfaces **114**, **116** do not contact back walls **146** and **150**, the filler material Obstructs the slot between the tip of the wicker and back wall **146**, so that wellbore fluid cannot pass through slot **144** or **148**. As with other embodiments described herein, fouling on sealing surfaces **114**, **116** is displaced toward slots **144**, **148** and urged through those slots axially away from sealing surfaces **114**, **116**.

Referring to FIG. **5**, OD helical slots **158** and ID helical slots **160** extend helically along outer diameter sealing surface **162** and inner diameter sealing surface **164**, respectively, of u-shaped seal member **166**. As with other slots, helical slots **158**, **160** can be filled with a filler (not shown in FIG. **4**), such as a metal that is softer than the metal of u-shaped seal member **166**, or can be formed without an filler. Fouling that is present on housing sealing surface **114** (FIG. **1**) or hanger sealing surface **116** (FIG. **1**) when u-shaped seal member **166** is energized can travel along helical slots **158**, **160**, respectively, to a point that is beyond sealing surfaces **114**, **116** (FIG. **1**).

Still referring to FIG. **5**, a circumferential groove **170** is shown. Circumferential groove **170** extends around the circumference of outer diameter **162**. An inner diameter circumferential groove (not shown in FIG. **5**) can extend around inner diameter **164** of u-shaped seal member **166**. Fouling that is present on sealing surfaces **114**, **116** (FIG. **1**) when u-shaped seal member **166** is energized can travel along circumferential groove **170** until reaching helical slots **158**, and then travel along helical slots **158** to a point that is beyond sealing surfaces **114**, **116** (FIG. **1**). Circumferential grooves can also be used with axial grooves as shown in FIG. **2**.

While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention.

What is claimed is:

1. A wellhead assembly comprising:

an outer tubular wellhead member having an axis;

an inner tubular wellhead member, the inner tubular wellhead member being operable to land within the outer tubular wellhead member, defining a seal pocket between them;

a wellhead member sealing surface on at least one of the wellhead members;

wickers formed in the wellhead member sealing surface, the wickers comprising a plurality of circumferentially extending, parallel ridges;

an annular sealing ring disposed within the seal pocket, the annular sealing ring having a sealing ring surface operable to be urged against the wickers in the wellhead member sealing surface;

the sealing ring surface having a plurality of circumferentially spaced apart sealing ring grooves extending from a first end toward a second end of the sealing ring surface, one of the ends of the sealing ring surface being above the other of the ends of the sealing ring surface, each of the sealing ring grooves having a back wall recessed from the sealing ring surface and having a groove radial depth that is less than a sealing ring radial thickness measured at the sealing ring surface; wherein

the sealing ring grooves provide flow paths for fouling material trapped in the wickers as the sealing ring surface is urged against the wickers; and

when the sealing ring is fully set, the wickers will have deformed the sealing ring grooves and closed off the flow paths.

2. The assembly according to claim **1**, wherein each of the sealing ring grooves has an upper end and a lower end that are spaced apart from each other greater than an axial distance from a lowermost one of the wickers engaged by the sealing ring surface to an uppermost one of the wickers engaged by the sealing ring surface.

3. The assembly according to claim **1**, wherein the sealing ring surface is urged toward the wellhead member sealing surface until the wickers contact the back walls of the sealing ring grooves.

4. The assembly according to claim **1**, wherein the sealing ring grooves are generally parallel to the axis of the sealing ring.

5. The assembly according to claim **1**, wherein the sealing ring grooves extend helically from the first end toward the second end of the sealing ring surface.

6. The assembly according to claim **1**, further comprising at least one circumferential groove in the sealing ring surface, the circumferential groove extending circumferentially around the sealing ring and intersecting at least one of the sealing ring grooves.

7. The assembly according to claim **1**, wherein:

the sealing ring grooves are filled with an inlay of a material different than a material of the sealing ring surface; and

the material of the inlay is selected to flow from the sealing ring grooves in response to the sealing ring surface being urged against the wickers.

8. The assembly according to claim **1**, wherein:

the sealing ring surface is metal and the sealing ring grooves are filled with a second metal, the second metal being softer than the metal of the sealing ring surface; and the second metal is selected to flow from the sealing ring grooves as the sealing ring surface is urged against the wickers.

9. The assembly according to claim **1**, wherein the wellhead member sealing surface is located on an inner diameter of the outer tubular wellhead member and the sealing ring grooves are on an outer diameter of the sealing ring.

10. The assembly according to claim **1**, wherein the sealing ring is a u-shaped seal that is energized by an energizing ring.

11. A method for forming a seal between an inner tubular wellhead member and an outer tubular wellhead member, at least one of the wellhead members having a wellhead member sealing surface containing a plurality of wickers, the method comprising:

(a) positioning a metal annular sealing ring in an annulus between the inner tubular wellbore member and the outer tubular wellbore member, the annular sealing ring having a plurality of grooves extending from a first end toward a second end of a sealing ring surface of the annular sealing ring, one of the ends of the sealing ring surface being above the other, each of the grooves having a back wall recessed from the sealing ring surface and having a groove radial depth from the back wall to the sealing ring surface that is less than a sealing ring radial thickness measured at the sealing ring surface;

(b) energizing the annular sealing ring by urging the sealing ring surface and the grooves toward and against the wickers; and

(c) flowing fouling material trapped in the wickers through the grooves and away from the wickers as the wickers deform the sealing ring surface.

12. The method according to claim **11**, wherein step (b) further comprises urging the sealing ring surface against the wickers until the wickers deform the grooves and contact back walls of the grooves.

13. The method according to claim **11**, wherein step (b) further comprises urging the sealing ring surface against the wickers until the wickers deform and close off flow paths created by the grooves.

14. The method according to claim **11**, further comprising the step of filling the grooves with metal that is softer than the metal of the sealing ring, and step (c) comprises flowing the metal in the grooves from the grooves.

15. The method according to claim **11**, wherein step (a) further comprises providing each of the plurality of grooves with a lower end and an upper end, an axial distance from the lower end to the upper end being greater than an axial distance from a lowermost one of the wickers engaged by the sealing ring surface in step (b) to an uppermost one of the wickers engaged by the sealing ring surface in step (b).

16. The method according to claim **11**, wherein the annular sealing ring further comprises at least one annular groove intersecting the plurality of grooves, and further comprising the step of urging the fouling material through the annular groove toward at least one of the plurality of grooves.

17. A wellhead assembly comprising:

an outer tubular wellhead member having an axis and a plurality of wickers comprising circumferentially extending ridges on an inner diameter sealing surface;

an inner tubular wellhead member, the inner tubular wellhead member being operable to land within the outer tubular wellhead member, defining a seal pocket between them;

an annular sealing ring disposed within the seal pocket, the annular sealing ring having an outer diameter sealing ring surface operable to be urged against the inner diameter sealing surface; and

the sealing ring surface having a plurality of circumferentially spaced apart sealing ring grooves, each of the sealing ring grooves having a back wall recessed from the sealing ring surface and having a groove radial depth from the back wall to the sealing ring surface that is less than a radial thickness of the sealing ring measured at the sealing ring surface;

each of the sealing ring grooves having a lower end and an upper end, with an axial distance from the lower end to the upper end being greater than an axial distance from a lowermost one of the wickers engaged by the sealing ring surface to an uppermost one of the wickers engaged by the sealing ring surface; and wherein

urging the sealing ring surface against the inner diameter sealing surface causes the wickers to embed into the sealing ring surface, and the sealing ring grooves define flow paths for fouling material trapped in the wickers to flow axially from the wickers.

18. The assembly according to claim **17**, wherein the sealing ring surface is urged toward the inner diameter sealing surface until the wickers contact the back walls of the sealing ring grooves.

19. The assembly according to claim **17**, wherein each of the sealing ring grooves extends helically from the lower end to the upper end of the sealing ring grooves.

20. The assembly according to claim **17**, wherein the sealing ring grooves are filled with an inlay of a material different than a material of the sealing ring surface, the material of the inlay being selected to flow from the sealing ring grooves as the sealing ring surface is urged against the wickers.

* * * * *